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Interactive comment on "A climate index for the Newfoundland and Labrador shelf" *by* Frédéric Cyr and Peter S. Galbraith

Barbara Berx (Referee)

b.berx@marlab.ac.uk

In "A climate index for the Newfoundland and Labrador shelf", Cyr and Galbraith present a new method to combine ten meteorological and physical oceanographic quantities into a single indicator for the shallow shelf areas adjacent to Newfoundland and Labrador, Canada. The manuscript is well written with a good structure. In a small number of instances, the language on how the indicators were calculated could be clarified further to avoid ambiguity. The provision of index time series that can be applied in marine research is very welcome, and I do appreciate the efforts the authors to translate measurements across the region into a meaningful data product. However, I did have some more significant questions on the calculations, on the index and what it means from an oceanographic perspective and its subsequent relationships through

the marine food web.

These questions/suggestions may be more significant to address, hence my choice for major revisions, but I would strongly encourage the authors to consider these and respond to the review as I can see great benefit to a comprehensive manuscript to accompany what I can see as a valuable data product.

Item 5 below, I would personally consider to merely improve the manuscript, and more importantly the application and use of the data product by others, and I would welcome the authors to make their own decision on whether or not to put in the effort to address this.

1) Calculation of some of the sub-indices: I have some questions around the method and choice of some of the sub-indices, their combination and/or inclusion.

- 2.1 NAO: The choice of the EOF-based NAO means that technically the time series will be slightly different each year (due to the nature of the analysis). Similar to the information highlighted in the Hurrell product, the users of the NLCI should be made aware that this means they do need to download the entire time series annually (rather than add a single value to the end of their time series). The authors could avoid this requirement by choosing the alternate NAO data product. If the current method is maintained, the caveat does need to be made explicit to ensure awareness with end-users.

- 2.2 Air Temperature: The inclusion of the more remote sites of Nuuk and Iqaluit needs some further explanation. How does weather at these remote sites impact ocean state on the Labrador and Newfoundland Shelf? Looking at Figure 3 (but please note my comment on the figures in point 4), it looks like the sign of anomalies at these sites is at times opposite to those more local to the Labrador and Newfoundland Shelf. The authors may want to consider giving the local and remote weather conditions separate weight in their combined index. The analysis of how the different component indices correlate may also show some stronger/clearer signals if this is done.

- 2.3 Sea Ice: The language around the calculation of combining the 6 time series (2 variables over 3 regions) is somewhat ambiguous. My understanding is that normalised anomalies were calculated and then averaged (arithmetic mean), correct?

- 2.4 Iceberg Count: The region where the measurement is made should be included in the map in Figure 1.

- 2.5 Station 27: The climatological conditions at Station 27 suggest the region stratifies to some extent throughout the year (see suggestion on isopycnals for Figure 7). The vertical average temperature and salinity may therefore be masking important variability in the near-surface and near-bed layer which may be driven by different processes. The authors also describe a three-layer system at the sampling location, which to me suggests that a vertical average is possibly not the most representative of on-shelf conditions. The complete lack of significant correlation of the S27 salinity is one indication to me that the choices here should be reconsidered. Some questions for the authors to consider are: could S27 surface and near-bed salinity and temperature be treated separately? Is one of these more/less relevant for the ecosystem of the region (for example, are there known links between fish stocks and recruitment success and one/several of these climate variables?)? Could the strength of stratification (for example expressed as potential energy anomaly) or the size of salinity/temperature range in the year be more important (on lines 115-117 the authors highlight the importance of the salinity cycle, but this is not adequately reflected in the sub-index or eventual climate index). Generally, salinity is a good indicator of circulation change, and therefore I would have suspected it to play a more important role, particularly due to the sub-polar gyre's influence on the region (see also item 3 below).

- 2.8 Bottom temperature: What is the reason for choosing the 1000 m isobath to delimit the extent of the shelf? Most publications consider the boundary to be the 200 or 500 m isobaths. Does this broader extent increase data availability? Is it because this is what the fisheries assessments use? Does this definition mean that a significant portion of water masses from deeper in the Labrador Sea is included? How does

this inclusion of deeper water (which is likely not influence by the same processes as the shallow shelf region) significantly impact on the bottom temperature mean and its seasonal/inter-annual variability?

2) The oceanographic understanding behind the combined index: This index will be very valuable to other marine scientists studying the ecosystem dynamics and productivity of the region. There is little interpretation of this throughout the manuscript (see item 5 below), but I also wonder if the combined index across so many components can provide a meaningful overview of the ocean state of the region. A good test is to see whether a schematic diagram could be drafted which indicates the generalised conditions of a positive/negative phase of the index. As mentioned below, the manuscript also lacks an indication of how the combined index (as well as the individual sub-indices) could be a driver of variability in the wider marine ecosystem of the region.

In addition, the choice of annual mean anomalies for some of the quantities also needs justification. The drivers of variability on shallow shelf environments can be different between winter-time and summer-time, therefore averaging across the year could be masking changes in one particular season. From the marine ecosystem impacts, consistent change in one season may be driving the variability of spawning/survival/recruitment... I would encourage the authors to review whether their choice of averaging periods is not masking such consistent differences in inter-annual change of the seasonal variability, and is therefore providing the most meaningful information for marine scientists researching the biogeochemical and ecosystem components of the region.

3) The lack of an index on sub-polar gyre strength: There has been no consideration of sub-polar gyre strength in any of the indices considered. Did the authors consider its inclusion? Is this basin-scale driver unimportant of the Newfoundland and Labrador Shelf region?

4) Figures: I must admit I very much dislike the stacked bar graph as a method of visualising the anomalies (sorry!). I find it very difficult to see the common variability (or not) across the different component indices, and would recommend the authors instead create a grid of the anomalies (see for example, the overview tables of the the ICES report on ocean climate and https://marine.gov.scot/sma/sites/default/files/omr_hadisst_temp_2018_yearlyanoms_landscape.png). The top or bottom row of such a grid could be the combined sub-index as is currently shown in figures. Figure 12 most definitely needs revising (I am not sure what the text in its caption alludes to) to consider such an approach. Such a grid would also make it more readily identifiable where the combine index is based on a smaller subset of the sub-indices due to the lack of data (see also my comment on an overview table below).

5) The Climate Index and what it means: Within marine ecosystem research, the use of single indices by researchers beyond the native discipline is attractive. Ideally, these indices are a single time series that integrate the state of the physical environment. Such indices do also however need to have a clear summary of what it means when they are positive/negative. This should be summarised in an expert statement which non-expert users can understand and refer to in their own research and publications. I will try to explain this point with an example.

For example, the North Atlantic Oscillation Index is a single time series which summarises the state of the atmosphere in the North Atlantic. The index has a clear definition (or two if you separate the calculation method into station-based and EOF-based), and this is associated with clear statements on what a positive/negative phase means for the prevailing weather conditions in North America/Northern Europe. There is a generally accepted data provider, who also provides a clear guide to non-expert users to aid the interpretation and use of this time series (see https://climatedataguide.ucar.edu/climate-data/hurrell-north-atlantic-oscillation-nao-index-pc-based). This means that any interested scientist can down-

load the time series easily (and freely), and review the expert guidance to ensure they are aware of its applicability and limitations and use it appropriately (or not, but at their own risk). As the data provider, it does require a certain "letting go" of responsibility and ownership, as end users will take your data and use it however they see fit. It also reduces the requirement on experts to spend time liaising with each individual user on what the index time series means for their data/analysis/. . .

In my opinion, it is advantageous to release some of this expert guidance with the manuscript as it will aid the end user and will broaden the application the end product. As is, I think this additional expert guidance and interpretation is missing from the manuscript, and I would therefore recommend the authors consider including a "what the NLCI means for the state of the region's seas" section. I would also suggest that some of this is elaborated for each of the sub-indices too.

In the end, I do think it is up to the authors to consider inclusion of such a section. They will need to make a decision on whether they consider this a data product which is freely available but where end-users will need to make contact and collaborate to aid in the meaningful interpretation of the end-user's data, or whether this is a data product which comes with a sufficient level of expert guidance that allows end-users to make their own attempts with interpretation (but where they may still approach the authors for expertise if desired). There is no correct answer here (and different authors/reviewers will have their own bias), but the NAO Index products provide an example of what could be achieved (and how to do it well).

Other minor comments:

General: consider adding an overview table with sub-index, data source, time period covered, calculation method.

Line 16: Although an annual update is stated, the likely publication time within the year is not defined. Some end-users may want to know whether this update will be in Spring/Summer/Autumn/Winter to know whether they can expect it when they are

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undertaking their own annual assessments (for example, for inclusion in an annual stock forecast for stock assessments which may be undertaken at a specific time of year). Such a statement could be appropriately "hedged" to avoid over-committing (or unexpected set-backs): "An annual update of the NLCI will likely be available by early summer each year. "

Line 27-28: It may be worth consider for the future 2020 update to create versions referenced to both the 1981-2010 and the 1991-2020 period to highlight to end-users the possible impacts of the change in reference period (or include an expert guidance statement to provide this information).

Line 51: Are these the normalised anomalies of the annual mean, or the annual mean anomalies? Line 130-131: Add reference to some of the recent papers documenting this fresh anomaly in the sub-polar North Atlantic (such as Holliday et al, 2020).

Line 143: The choice of BB as Bonavista is a little confusing, particularly as Baffin Bay is also part of the overall region, and generally abbreviated as BB.

Figure 7: Isopycnals on both panels could provide a good addition.

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